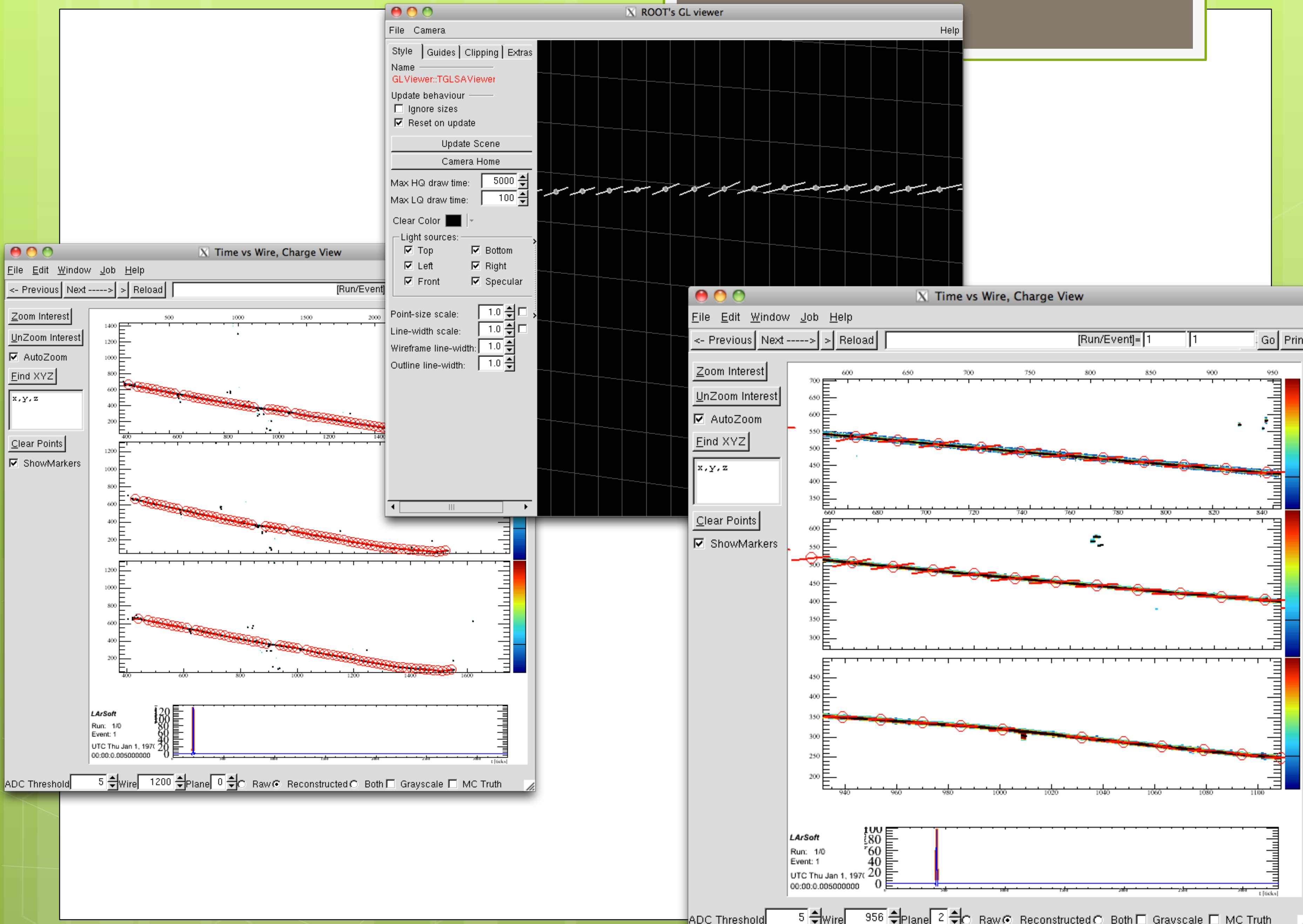
Seed Update

LArSoft Tracking Group

Ben Jones, MIT

Seed Finding (Basic)

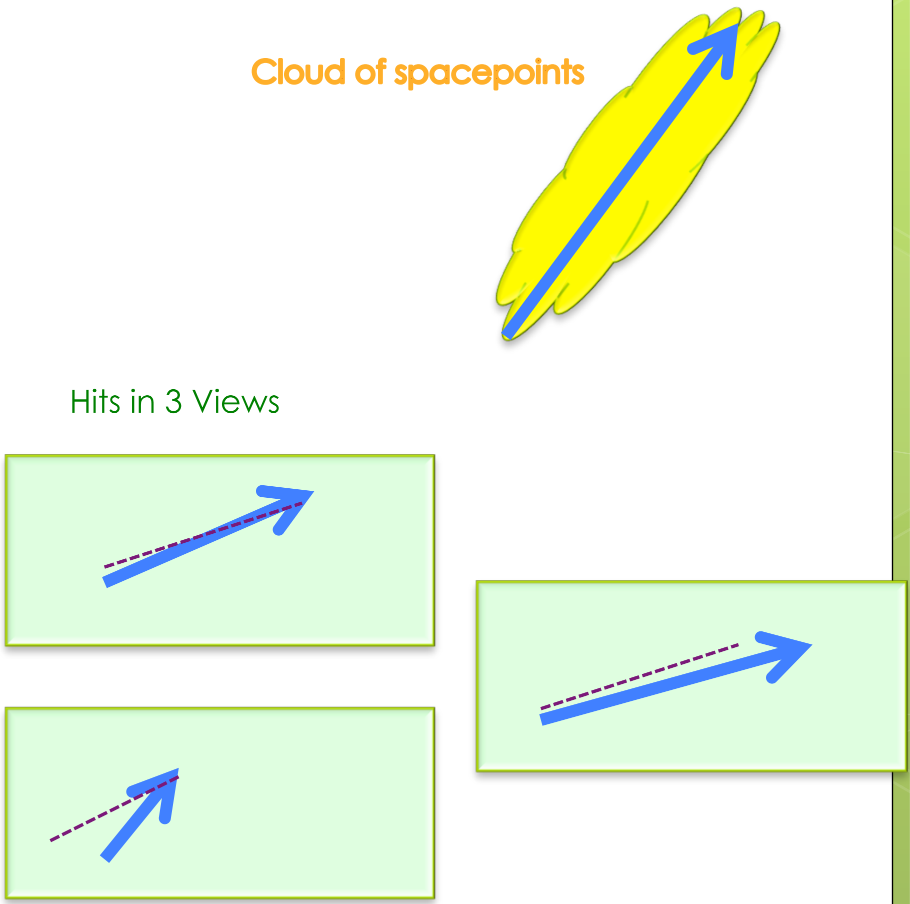
- Look for a collection of spacepoints with a strong directionality:
  - Take a spacepoint at high Z
  - Locate all those within some distance
  - Find the centre of mass, and find average theta and phi for spacepoints from this position
  - If $(\Delta\theta)^2 + (\sin\theta\,\Delta\Phi)^2 < C^2$, these points form a seed.



ROOT's GL viewer
File Camera Help
Style Guides Clipping Extras
Name
GLViewer::TGLSAViewer
Update behaviour
Ignore sizes
Reset on update
Update Scene
Camera Home
Max HQ draw time: 5000
Max LQ draw time: 100
Clear Color
Light sources:
Top Bottom
Left Right
Front Specular
Point-size scale: 1.0
Line-width scale: 1.0
Wireframe line-width: 1.0
Outline line-width: 1.0
Time vs Wire, Charge View
File Edit Window Job Help
<- Previous Next -----> > Reload [Run/Event]= 1 1 Go Print
Zoom Interest
UnZoom Interest
AutoZoom
Find XYZ
x,y,z
Clear Points
ShowMarkers
LArSoft
Run: 1/0
Event: 1
UTC Thu Jan 1, 1970
00:00:0.005000000
ADC Threshold 5 Wire 1200 Plane 0 Raw Reconstructed Both Grayscale MC Truth
ADC Threshold 5 Wire 956 Plane 2 Raw Reconstructed Both Grayscale MC Truth

The Magic Refits

- Now we have a group of spacepoints, we can ask them all for their hits.
- We count each hit only once, and catalogue them into views
- Then adjust seed to better match the set of hits in each view



Refit Procedure

- 2 stages, each repeated many times:
  - 1: Centre of Seed Refit
  - 2: Direction Refit

Stage 1: Seed Centre Refit:

Time coordinate is easy –

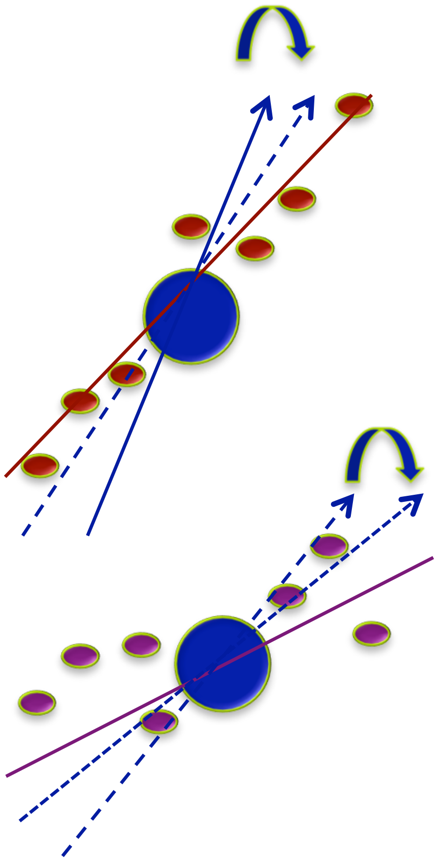
take weighted average of hit times to be the new x coordinate.

Space coordinate is hard –

Cooridnate degeneracy. Also the direction depends on the chosen central point.

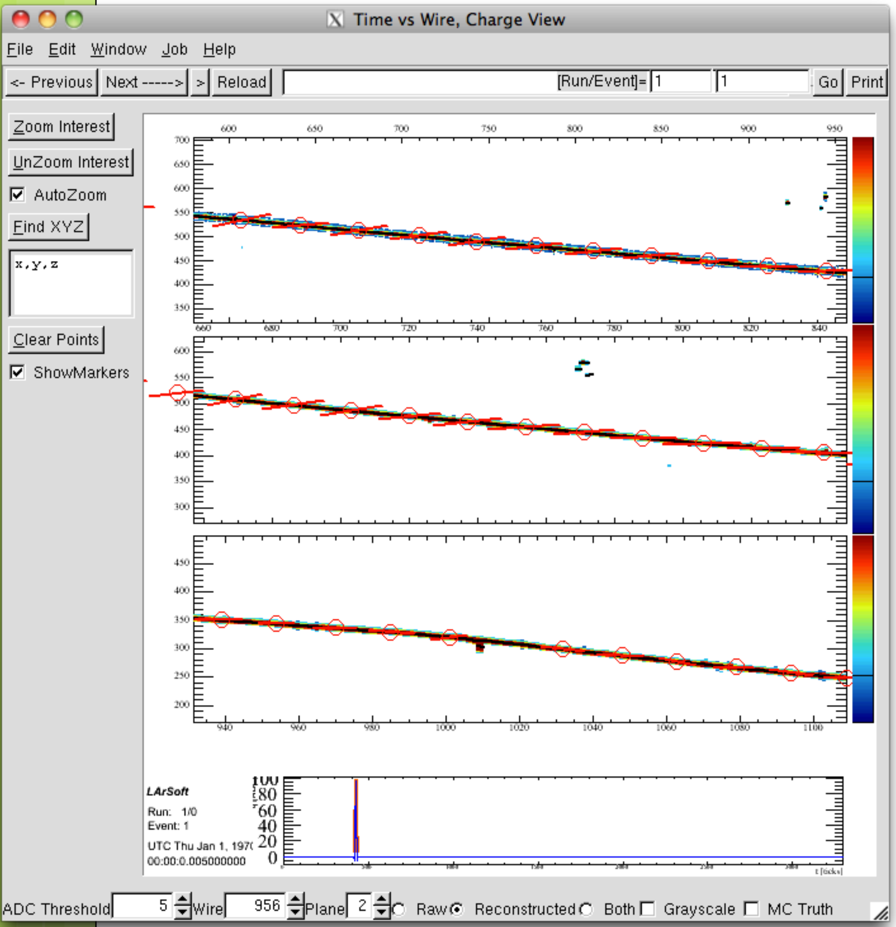
To iterate towards a stable compromise between the views, in each iteration we move the seed center half way from its current position and the favorite position, in the direction constrained by each view individually.

- **Stage 2 : Direction Refit**
  - Now we have moved the seed centre, perform least squares fit to determine favorite direction in each view.
  - Rotate seed half way towards the new favorite direction in the plane, leaving the out-of-plane gradient unchanged.
  - Performing stage 1 then stage 2 many times (~20) leads to refitted seeds which much better represent the charge deposits than the spacepoint based seeds.
  - **We used spacepoints to locate the right hits (the slow part of most algorithms), then hit information to assign the seed position and direction so we are freed from combinatoric problems.**

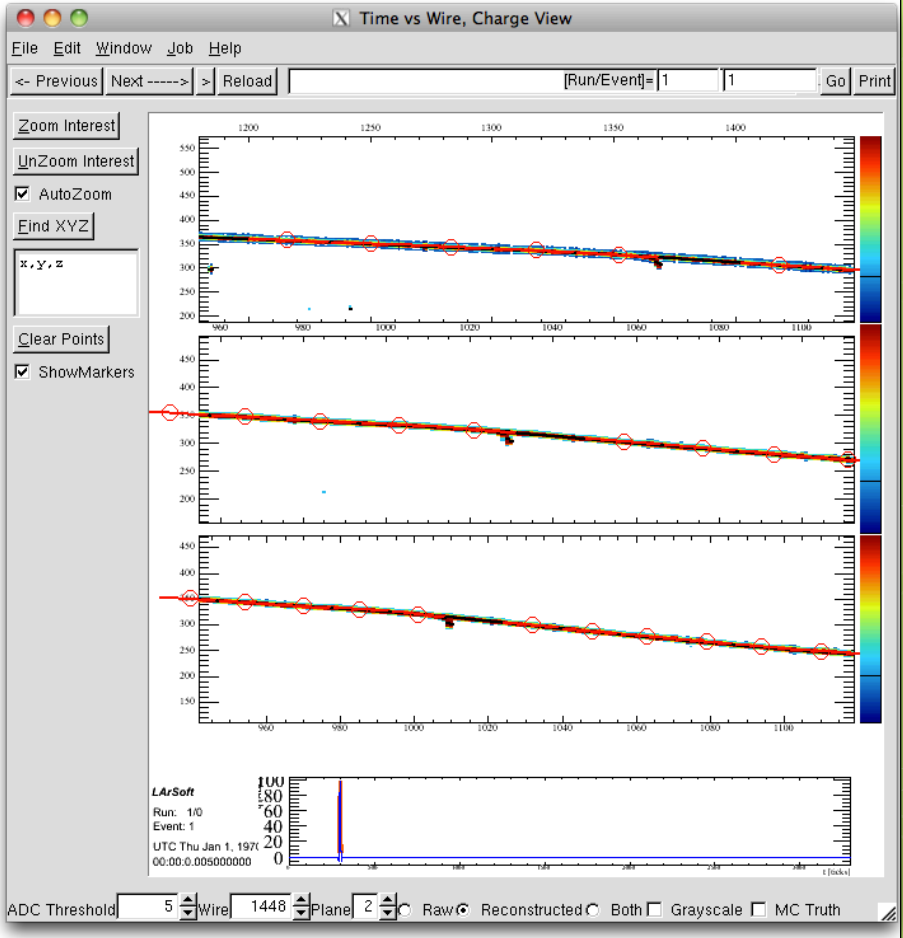


Repeat ~20 times, iterating to stable solution

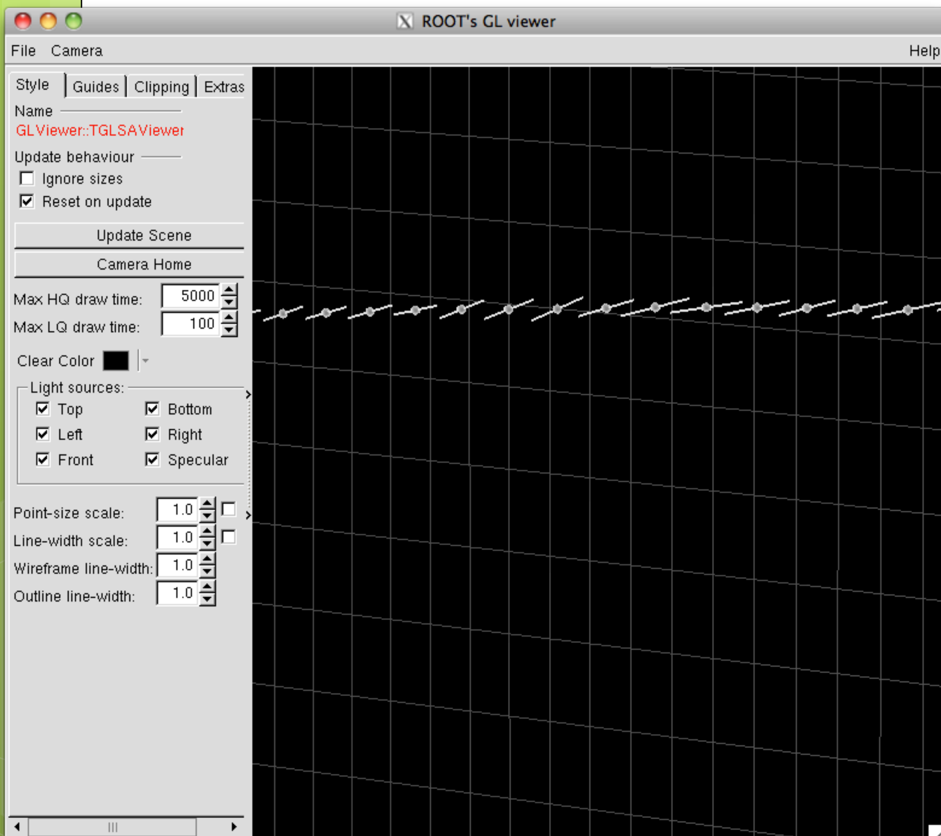
No refit



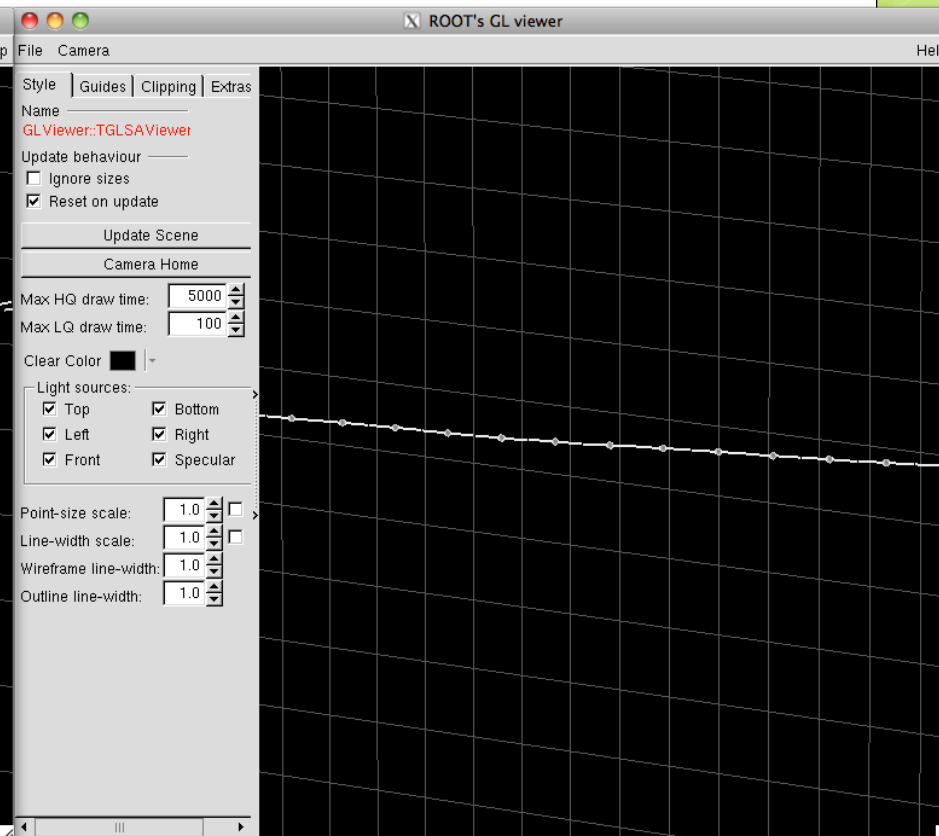
With refit



No Refit



With Refit

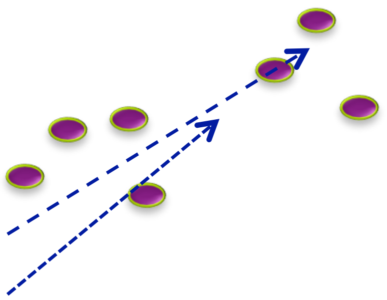


Extendable Seeds

- 2 goals:
  - 1) Efficient 3D reconstruction of straight track sections, no matter how long, using all views simultaneously
  - 2) Interpolating through difficult regions by simple extension of a previously found track segment

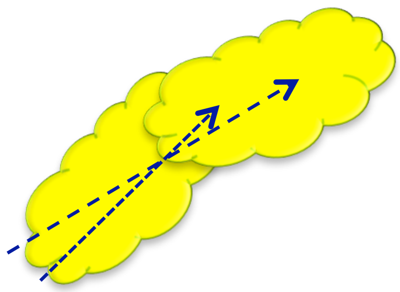
Seed Extension Procedure

- 1) Find a seed in the usual way, with some fixed starting length (present value = 2cm)
- 2) Refit to hits, calculate RMS in each view
- 3) Walk it out *p* mm past end 1 (present value = 1cm).
- 4) Check which spacepoints are nearby and get their hits
- 5) Refit to hits again to get new optimal seed position and direction
- 6) Decide whether to keep this extension (next slide)
- 7) If so, try to extend again. If not, keep last acceptable seed, and start extending at other end.



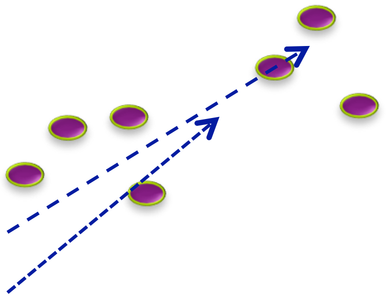
Conditions for Keeping Extension

- 1) N_{i+1} > N_i
- 2) RMS_{i+1} < RMS_i / f
- 3) dN/dx_{i+1} > $f\ dN/dx_i$



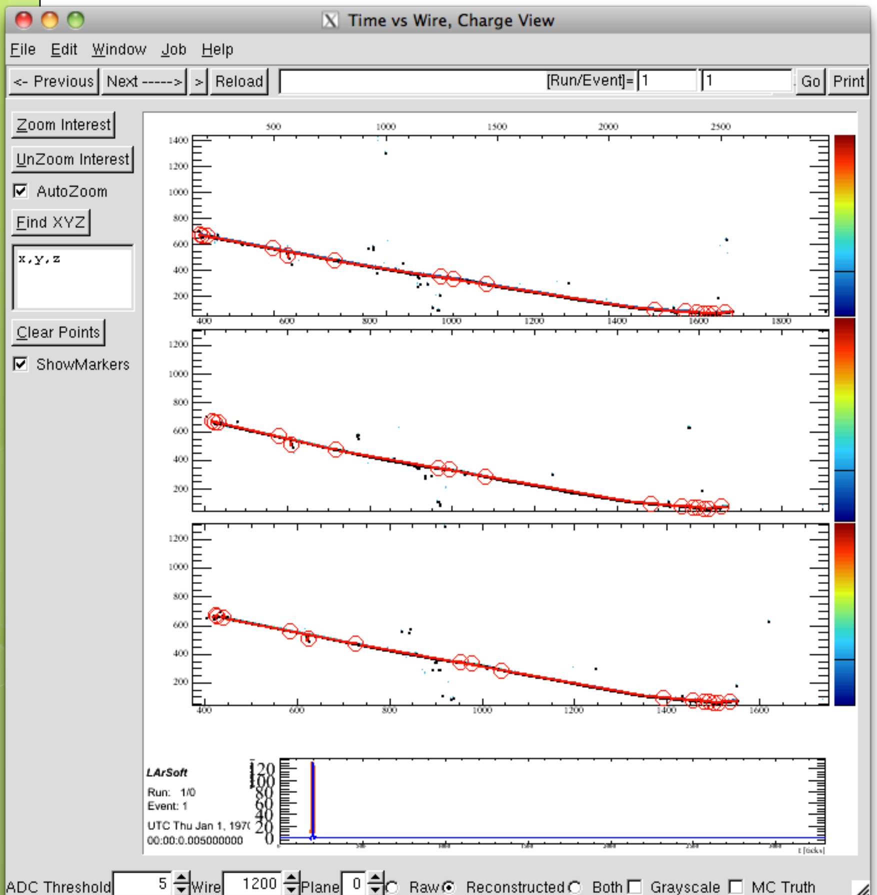
N: No of distinct hits in all seed spacepoints

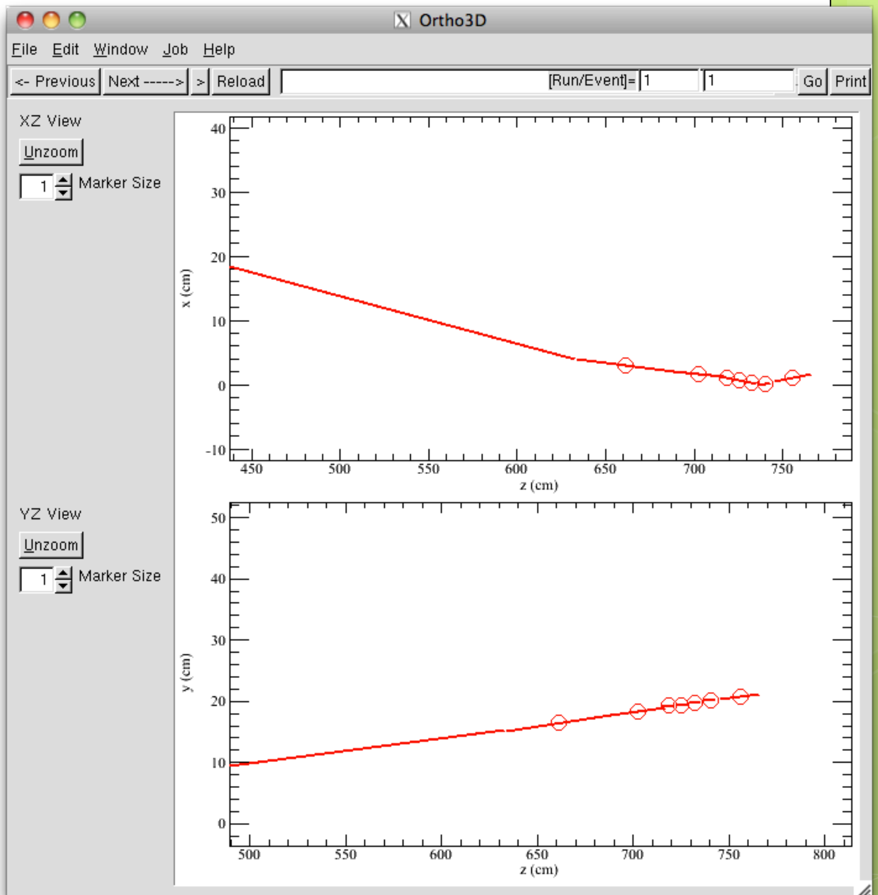
RMS: of projected distances from seed spine to all hits collected



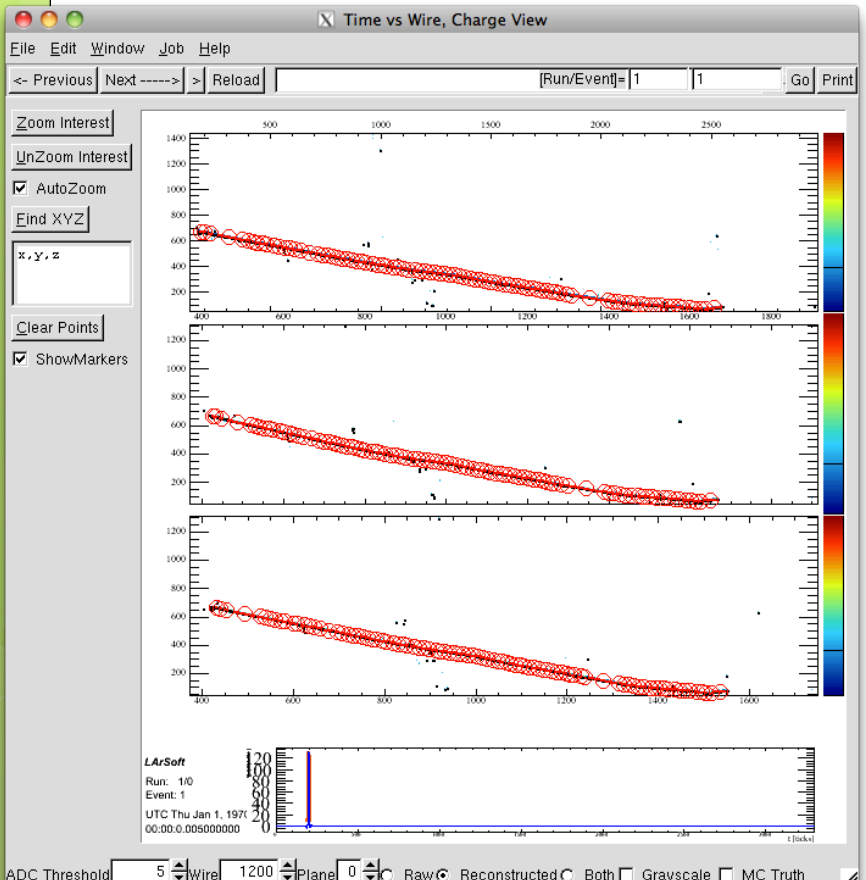
x: Length of seed

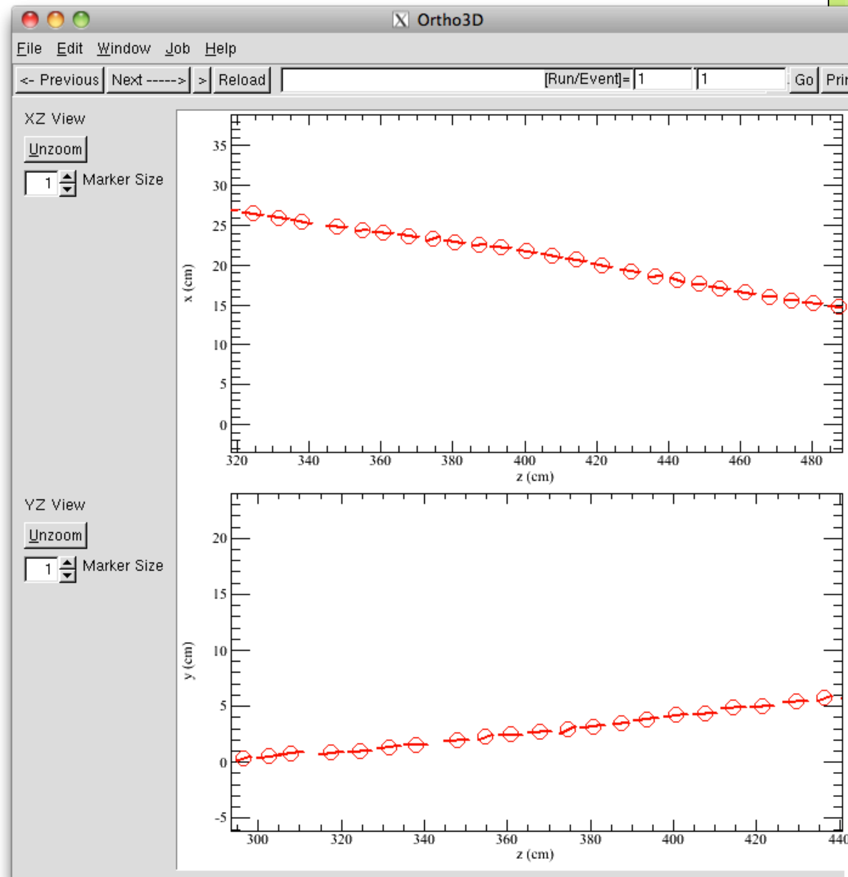
f: Extension threshold – parameter in algorithm

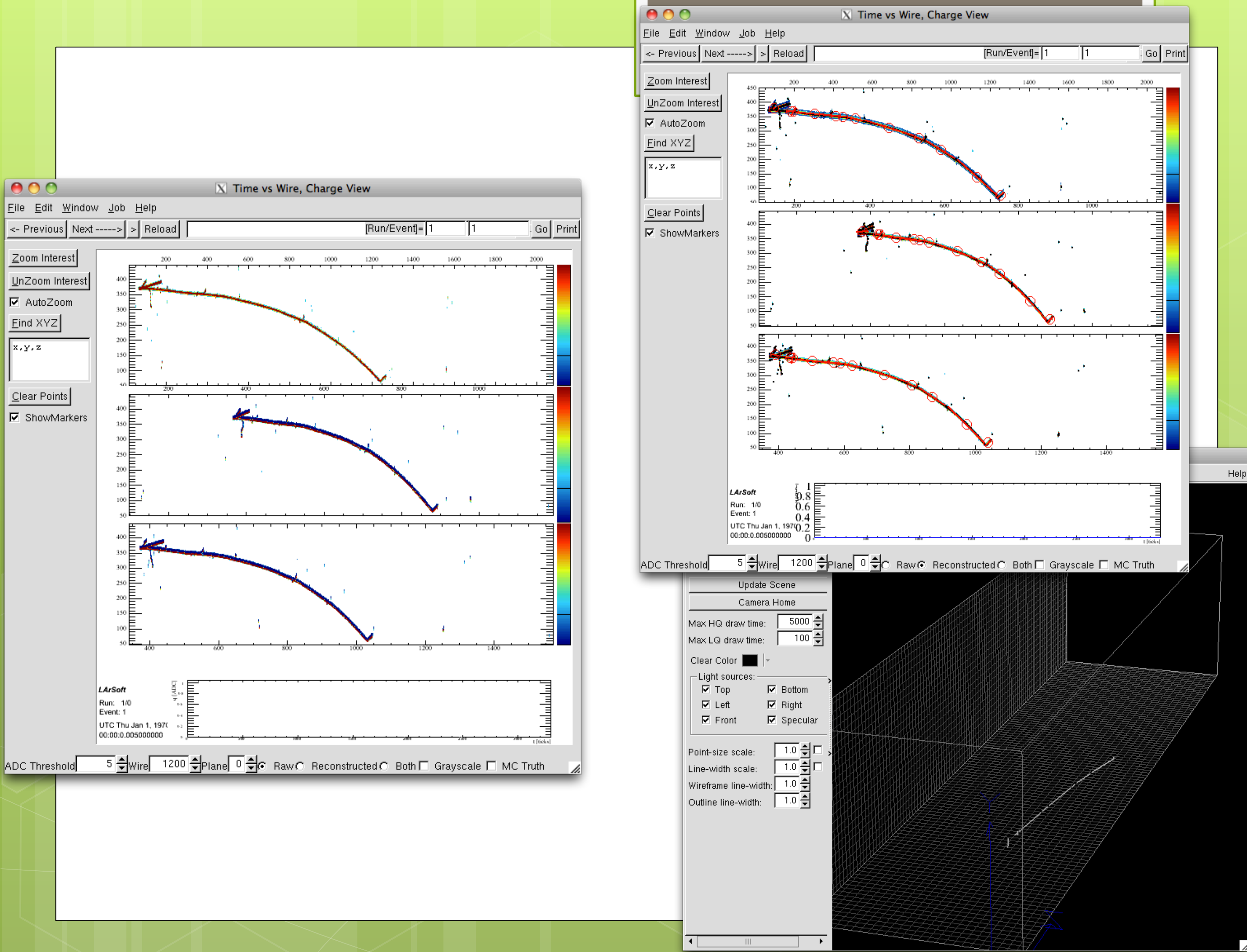




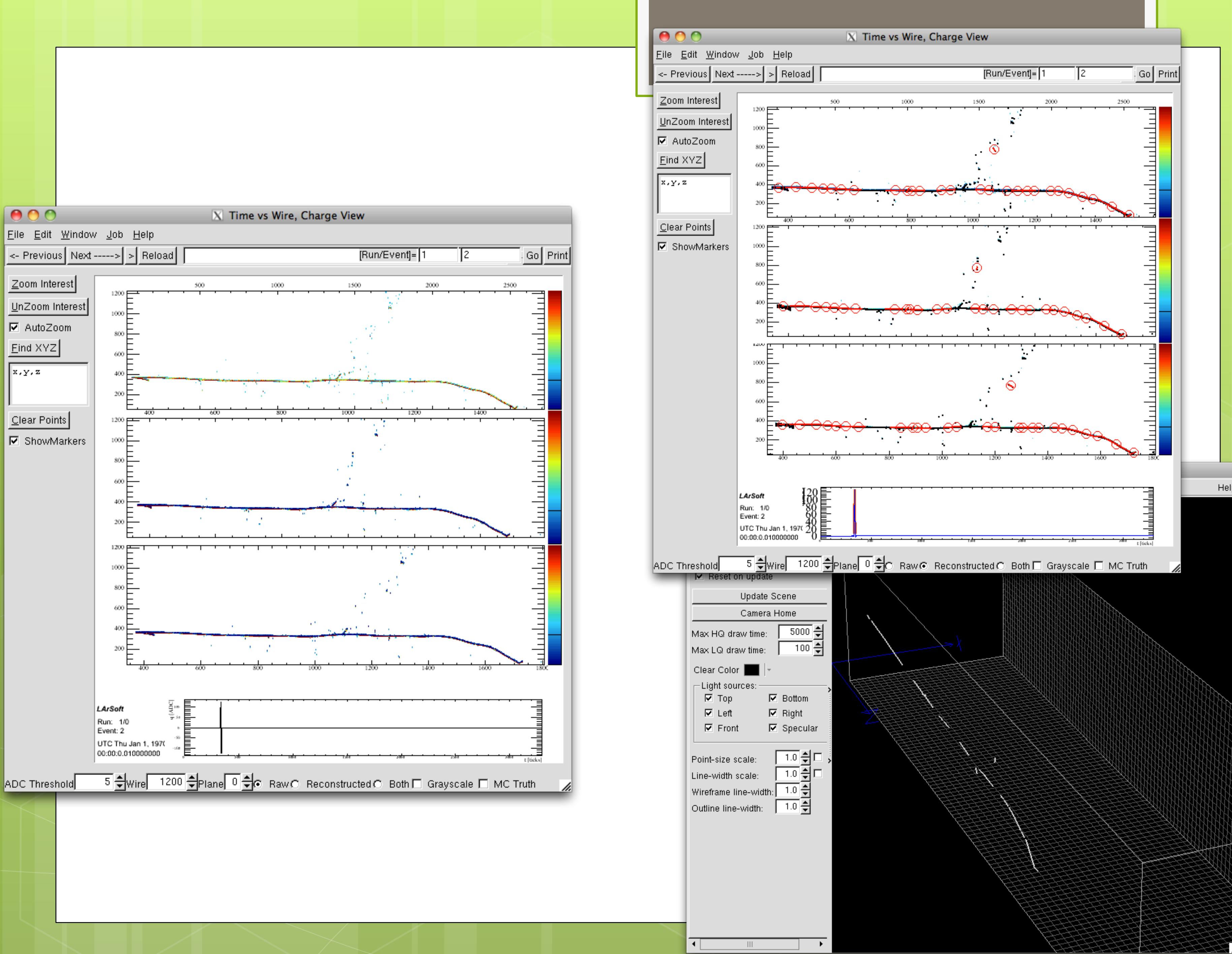
- Adjusting threshold lets you determine how segmented the track should be / how tightly the seeds have to hug hits

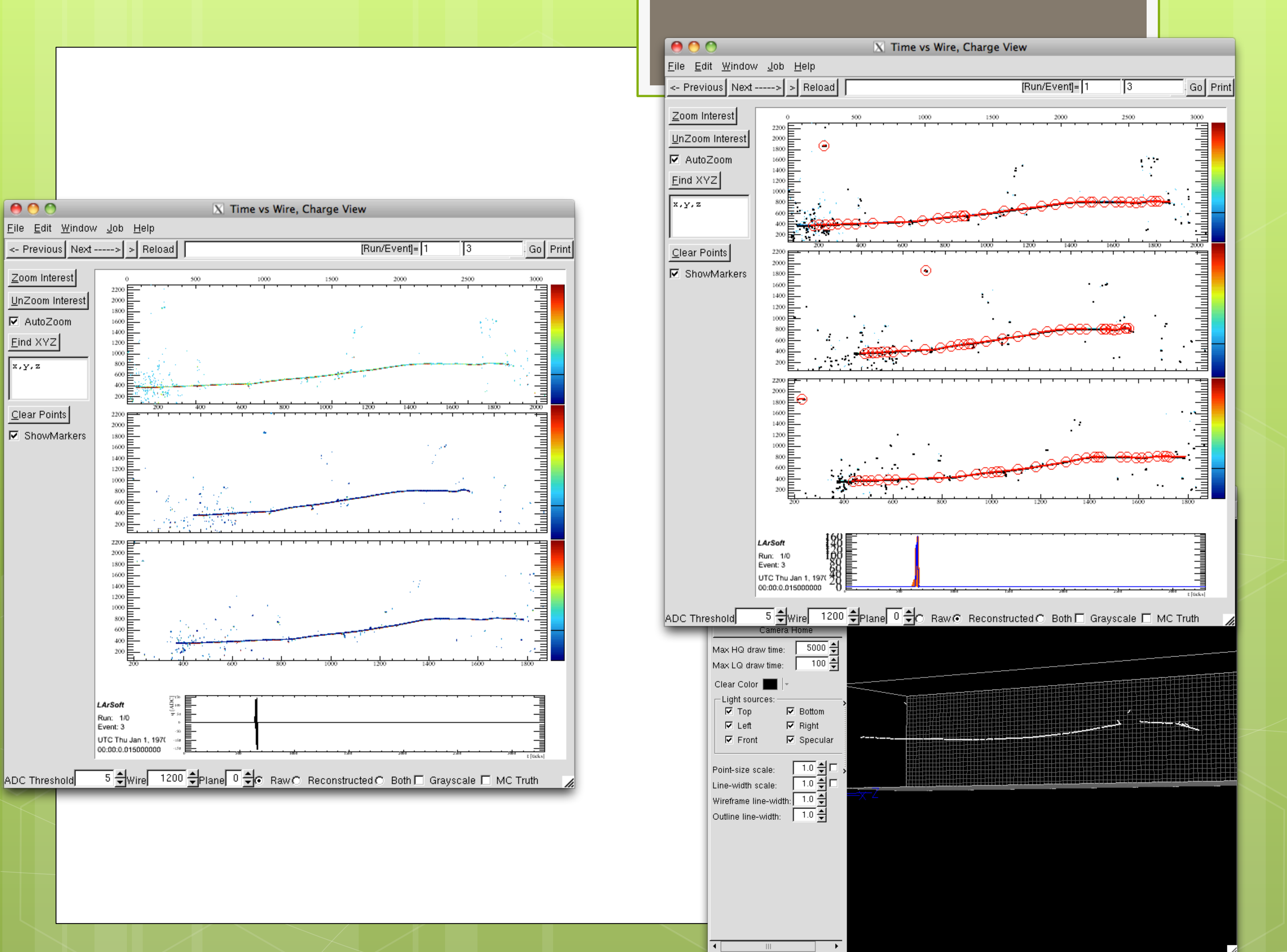

Time vs Wire, Charge View
File Edit Window Job Help
<- Previous
Next ----->
Reload
[Run/Event]=
Go
Print
Zoom Interest
UnZoom Interest
AutoZoom
Find XYZ
x,y,z
Clear Points
ShowMarkers
LArSoft
Run: 1/0
Event: 1
ADC Threshold
Wire
Plane
Raw
Reconstructed
Both
Grayscale
MC Truth


Ortho3D
File Edit Window Job Help
<- Previous
Next ----->
Reload
[Run/Event]=
Go
Print
XZ View
Unzoom
Marker Size
x (cm)
z (cm)
YZ View
Unzoom
Marker Size
y (cm)
z (cm)



Time vs Wire, Charge View
File Edit Window Job Help
<- Previous Next -----> > Reload [Run/Event]= 1 1 Go Print
Zoom Interest
UnZoom Interest
AutoZoom
Find XYZ
x,y,z
Clear Points
ShowMarkers
LArSoft
Run: 1/0
Event: 1
UTC Thu Jan 1, 1970
00:00:0.005000000
ADC Threshold 5 Wire 1200 Plane 0 Raw Reconstructed Both Grayscale MC Truth
Help
Update Scene
Camera Home
Max HQ draw time: 5000
Max LQ draw time: 100
Clear Color
Light sources:
Top
Bottom
Left
Right
Front
Specular
Point-size scale: 1.0
Line-width scale: 1.0
Wireframe line-width: 1.0
Outline line-width: 1.0


Time vs Wire, Charge View
File Edit Window Job Help
<- Previous Next -----> > Reload [Run/Event]= 1 2 Go Print
Zoom Interest
UnZoom Interest
AutoZoom
Find XYZ
x,y,z
Clear Points
ShowMarkers
LArSoft
Run: 1/0
Event: 2
UTC Thu Jan 1, 1970
00:00:0.010000000
ADC Threshold 5 Wire 1200 Plane 0 Raw Reconstructed Both Grayscale MC Truth
Time vs Wire, Charge View
File Edit Window Job Help
<- Previous Next -----> > Reload [Run/Event]= 1 2 Go Print
Zoom Interest
UnZoom Interest
AutoZoom
Find XYZ
x,y,z
Clear Points
ShowMarkers
LArSoft
Run: 1/0
Event: 2
UTC Thu Jan 1, 1970
00:00:0.010000000
ADC Threshold 5 Wire 1200 Plane 0 Raw Reconstructed Both Grayscale MC Truth
Help
Reset on update
Update Scene
Camera Home
Max HQ draw time: 5000
Max LQ draw time: 100
Clear Color
Light sources:
Top
Bottom
Left
Right
Front
Specular
Point-size scale: 1.0
Line-width scale: 1.0
Wireframe line-width: 1.0
Outline line-width: 1.0



Time vs Wire, Charge View
File Edit Window Job Help
<- Previous Next -----> > Reload [Run/Event]= 1 3 Go Print
Zoom Interest
UnZoom Interest
AutoZoom
Find XYZ
x,y,z
Clear Points
ShowMarkers
LArSoft
Run: 1/0
Event: 3
UTC Thu Jan 1, 1970
00:00:0.015000000
ADC Threshold 5 Wire 1200 Plane 0 Raw Reconstructed Both Grayscale MC Truth
Time vs Wire, Charge View
File Edit Window Job Help
<- Previous Next -----> > Reload [Run/Event]= 1 3 Go Print
Zoom Interest
UnZoom Interest
AutoZoom
Find XYZ
x,y,z
Clear Points
ShowMarkers
LArSoft
Run: 1/0
Event: 3
UTC Thu Jan 1, 1970
00:00:0.015000000
ADC Threshold 5 Wire 1200 Plane 0 Raw Reconstructed Both Grayscale MC Truth
Camera Home
Max HQ draw time: 5000
Max LQ draw time: 100
Clear Color
Light sources:
Top
Bottom
Left
Right
Front
Specular
Point-size scale: 1.0
Line-width scale: 1.0
Wireframe line-width: 1.0
Outline line-width: 1.0

Next Steps

- Apply Bezier or Kalman iterative procedure – find the long tracks, subtract them, re-seed for shorter ones
- Implement pitch-based calorimetric reco for Bezier tracks